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FAA Air Traffic Operational Evaluation of Automated Surface Observing System (ASOS)

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October 1990

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16. Abstract

This report details the results of the Federal Aviation Administration (FAA) Air Traffic Operational Evaluation of Automated Surface Observing System (ASOS) at the Tulsa International Airport, Oklahoma. The evaluation was conducted in order to obtain operational air traffic controller reaction to the AAI Corporation preproduction ASOS. The evaluation resulted in numerous recommendations to improve the ASOS prior to production.

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EXECUTIVE SUMMARY

The Automated Surface Observing System (ASOS) is a computer based-weather collection and display system that will be installed at airports having air traffic control towers (ATCT) and other selected locations. ASOS is an array of sensors, and communication ports engineered to provide airport weather observations accurately, continuously, and automatically to tower air traffic controllers via video displays, and to pilots via radio. The National Weather Service (NWS), under terms of a Memorandum of Agreement (MOA) with the Federal Aviation Administration (FAA), will procure, install, operate, and maintain the ASOS for the FAA.

An operational evaluation of a preproduction ASOS, developed by the AAI Corporation, was conducted at the Tulsa International Airport, Oklahoma, during the period April 23 to May 26, 1990. The objective of the evaluation was to obtain FAA air traffic controller reaction to the ASOS display and input equipment that was installed in the tower cab and radar room. This equipment consisted of one Operator Input Device (OID), four Controller Video Displays (CVDs), and one Video Display Unit (VDU). Questionnaire forms were used to obtain responses from controllers relative to operational suitability of these devices.

Highlights of the evaluation and subsequent debriefing are the following: (1) The OID man machine interface does not fit controller needs and requires revision; (2) The OID display and keyboard are too large for the limited space in the tower cab (smaller equipment is necessary); (3) The voice input and replay device needs to be redesigned for a tower cab environment (a lightweight push-to-talk (PTT) handset would be appropriate); (4) The CVDs were unreadable in sunlight and too "white" for the radar room (a new display that is suitable for both of these locations must be found); and (5) The weather message format, as presented on the CVD, was not "standard" and needs to be revised to meet the current weather message format.

There is a considerable amount of risk involved if the proposed changes from the Tulsa evaluation are incorporated into the specification without further evaluation by controllers from sites other than Tulsa. A second evaluation of the AAI Corporation preproduction ASOS, by a group of controllers from a cross section of FAA regions, is highly recommended to help ensure that the proposed changes, identified in this report, meet the needs of all controllers.

If a second evaluation on the preproduction system cannot be conducted, the recommendations derived from the debriefing should be integrated into the specification.

The issue of display readability is highly critical to operational acceptance and should be evaluated so that an appropriate display technology can be incorporated into the limited production systems.

It is also recommended that a user evaluation of the limited production ASOS be conducted prior to the decision for full deployment. The evaluation should be conducted at both the FAA Technical Center and a minimum of two operational sites, to accommodate a cross section of controllers.

INTRODUCTION

PURPOSE.

The purpose of this evaluation was to obtain Federal Aviation Administration (FAA) air traffic controller reaction to the AAI Corporation preproduction Automated Surface Observing System (ASOS). The input obtained from this evaluation is intended to be used to make required changes in the specification for ASOS. The evaluation was conducted by the Surveillance and Weather Systems Branch, ACN-230, of the FAA Technical Center. The plan for this evaluation is detailed in FAA Technical Note DOT/FAA/CT-TN89/56, Plan for the FAA Air Traffic Operational Evaluation of the Automated Surface Observing System (ASOS).

BACKGROUND.

The ASOS is a shared program under a signed Memorandum of Agreement (MOA) between the National Oceanic and Atmospheric Administration (NOAA) and the FAA. Under the MOA, the Administrator of NOAA agreed to provide ASOS services in four areas; (1) Acquisition, (2) Implementation, (3) Operations, and (4) Maintenance. The Administrator of the FAA agreed to compensate NOAA for these services on a cost reimbursable basis. The National Weather Service (NWS) has responsibility for all testing of the ASOS, with the exception of this evaluation.

ASOS is a computer-based system, consisting of an array of sensors and communication ports, engineered to provide continuous automatic airport weather observations to tower air traffic controllers via alphanumeric displays and to pilots via radio or phone. It will generate 1-minute observations, hourly Surface Aviation Observations (SAOs), and special and local observations. ASOS will report wind speed and direction, pressure, temperature and dew point, visibility to 10 miles, selected obstructions to vision, precipitation identification, intensity and amount, freezing rain, and sky condition to 12,000 feet.

The intent of the ASOS program is to implement automated weather observing systems which employ today's technology as a means of improving the weather services provided to the National Airspace System (NAS). At towered airports, ASOS will redirect the NWS activities from manual collection of weather data, to data quality control, and will provide a continous weather watch. At nontowered airports, ASOS will provide weather observation services that are not currently available.

The FAA has a planned requirement for at least 537 ASOSs of two different operational levels; (1) a nontowered or small airport level where there is currently no federal weather observing presence (233 systems), and (2) towered or larger airport level where there is an existing federal observing program (304 systems). There is a potential requirement for an additional 204 systems to be placed at nontowered sites.

Two contractors were competing for the ASOS production contract: AAI Corporation of Hunt Valley, Maryland, and Magnavox Electronic Systems of Fort Wayne, Indiana. The NWS in concert with the FAA, selected the Tulsa International Airport, Oklahoma, for field evaluations of the AAI Corporation preproduction ASOS, and the Wichita Mid-Continent Airport, Kansas, for evaluation of the Magnavox preproduction ASOS. (The Magnavox Electronic Systems contract was subsequently "terminated for the convenience of the government." The planned evaluation of the Magnavox system at Wichita will not be addressed in this report.)

METHOD

PARTICIPANTS.

During the evaluation period, there were 51 persons assigned to work at the Tulsa tower. Fifty of the assigned personnel participated in the training and the evaluation. The 50 evaluators were broken down as follows: 7 staff, 5 supervisors, and 38 Air Traffic Control Specialists (ATCSs). The Tulsa tower is utilized as a training hub for other towers in the region, consequently, many ATCSs were in some phase of air traffic training. Due to scheduling constraints and the short duration of the evaluation, personnel from other towers were not available to take part in the evaluation, as originally planned.

TRAINING.

Two representatives from the Tulsa tower received training on the system at the NWS Sterling Research and Development Center (SR&DC) in Sterling, Virginia on April 11 and 12, 1990. NWS training personnel were on-site at Tulsa, the week of April 16, to conduct training prior to the evaluation. The NWS, in conjunction with the Tulsa representatives, trained 14 tower personnel. ACN-230 assisted the tower personnel in training the remainder of the participants the following week. All personnel who received ASOS training were required to execute a nondisclosure statement because of the acquisition sensitive nature of the procurement.

EQUIPMENT.

The ASOS equipment that was evaluated consisted of an Operator Interface Device (OID), a Video Display Unit (VDU), and four Controller Video Displays (CVD). All displays were labeled NOT FOR OPERATIONAL USE. The installation of the ASOS display equipment in the tower was coordinated between AAI Corporation and Tulsa Airway Facilities (AF) personnel.

The OID was placed in the tower cab between the local control position and the ground control position. (The OID is intended for use at the Flight Data Operator (FDO) position, but lack of space prohibited it from being placed there). The OID consisted of a color monitor which displayed SAOs, 1-minute observations, local observations and archived data, along with a keyboard for entering remarks, cloud observations, tower visibility, and archiving ASOS

local observations. An associated keypad handset was included for entering information into the ASOS voice message system for voice output to pilots. (There was no radio broadcast of the voice information during the evaluation.)

The VDU, a monochrome monitor which displayed the latest hourly, special, or local 1-minute observations for use by tower supervisors, was installed in the radar room where the supervisors operate. This display was located approximately 20 feet from the supervisor's desk due to installation problems.

Four CVDs completed the equipment to be evaluated. Two CVDs were placed in the tower and two CVDs were placed in the radar room. They displayed SAOs, winds, altimeter, and a limited set of remarks. These units were designed utilizing an electroluminescent flat panel display. On the tenth day of the evaluation, one of the tower CVDs was removed and replaced by AAI Corporation with a "production model" CVD.

QUESTIONNAIRES.

Four questionnaires were utilized in the conduct of this evaluation. Three of the questionnaires (OID, CVD, and VDU) were structured to obtain the evaluation of ASOS by rating a statement about each feature/function on a seven-point scale ranging from "very good" to "very poor."

The OID questionnaire consisted of 42 questions divided into three categories; Display, System, and Keyboard/Microphone/Alarm (appendix A). To encourage usage of the OID, a scenario was developed to exercise all the functions (appendix B). All personnel were asked to complete this questionnaire.

The VDU questionnaire consisted of 16 questions divided into two categories; Display and System (appendix C). This questionnaire was for supervisory personnel only.

There were 19 questions on the CVD questionnaire divided into two categories; Display and System (appendix D). Controller personnel were asked to fill out this questionnaire.

The Summary questionnaire consisted of nine questions asking for written responses concerning the overall suitability of ASOS (appendix E). All personnel were requested to complete this questionnaire.

PROCEDURE.

The ASOS evaluation was conducted in two phases from April 23 to May 26, 1990. Phase I was conducted April 23 to May 5 in order to obtain controller evaluations after using the system for 1 week. Phase II was conducted from May 21 to May 26, after the controllers had used the system for 4 weeks. (Due to schedule constraints, the planned 6-week evaluation could not be conducted).

During the week of April 23, all participants were briefed by the ACN-230 evaluation conductor on the purpose of the evaluation, format of the questionnaires, response alternatives (appendix F) and conduct of both Phase I

and II of the evaluation. The Tulsa personnel were informed that participation in the evaluation was voluntary. The appropriate questionnaires for Phase I were provided to each participant at the end of the briefing. Each participant was asked to use the system for 1 week before they completed the questionnaire(s). A representative from ACN-230 was present during the Phase I evaluation period to answer any questions about the evaluation. The completed Phase I questionnaires were collected during the week of April 30, as each participant concluded their 1-week evaluation.

The ASOS displays were left in place at the end of Phase I. The ACN-230 representative returned May 21 to May 26 to handout and then collect the questionnaires for the Phase II, portion of the evaluation. In Phase II, the participants were asked to complete the identical questionnaires from Phase I, but to reevaluate the ASOS after having access to the system for 4 weeks.

POST-EVALUATION DEBRIEFING.

A post-evaluation debriefing was held at the Tulsa ATCT on July 12, 1990, to obtain additional user feedback on the changes necessary to make the AAI Corporation ASOS suitable for operational use. The debriefing utilized the "Executive Summary of the FAA ASOS Evaluation Conducted at Tulsa, OK," dated June 8, 1990 (appendix G), and the categorized comments from the Summary questionnaire (appendix H), as the framework for the discussion. The feedback from the debriefing has been incorporated into the Results and Discussion section.

ANALYSIS.

Numerical values were assigned to the questionnaire responses, (1 = Very Good to 7 = Very Poor, 0 = Do Not Know) and the mean response was computed for each questionnaire item. The means were analyzed to determine where the participants felt that ASOS did not meet their operational suitability needs, and to determine if there was a significant change in mean ratings between Phase I and II. The written responses from the summary questionnaires were analyzed using content analysis. These responses were categorized and quantified to provide additional controller feedback (appendix H).

RESULTS AND DISCUSSION

The following is a table of the number of completed questionnaires:

Questionnaire	Phase I	Phase II
OID	26	16
CVD	25	15
VDU	2	2
Summary	22	14
Total Completed	75	47

There was a much lower response rate on the second administration of the questionnaires. This may be due to the short interval between the two phases, and the controller workload in general. The low response on the VDU questionnaire, which covered the supervisory display, has two explanations. First there are only seven supervisors at the Tulsa tower. Second, the VDU, designed to be at the supervisory position, as mentioned earlier, was installed approximately 20 feet from the supervisory desk.

OPERATOR INTERFACE DISPLAY (OID).

The mean, standard deviation, and number of respondents for the OID questionnaire for both Phase I and II are presented in figure 1. Overall, there was no significant difference between the mean responses on Phase I (3.06) versus Phase II (2.86), both falling into the "Fairly Good" category.

Only one item, No. 29, "Effort required to recover from an input error," was rated "Fairly Poor" (Phase I only). Four items rated "Fair" in both Phase I and II, along with an additional five items rated "Fair" in either Phase I or Phase II, were related to the amount of effort required to perform routine tasks utilizing the OID Man Machine Interface (MMI). The low ratings on the amount of effort required were also echoed several places in the comments on the summary questionnaire (appendix G). Some comment categories are as follows:

1. Not user friendly - too many steps
2. Use single entry keys
3. Too many steps to input voice messages

From the debriefing it became clear that the issue of the amount of effort/time required to perform air traffic (AT) tasks utilizing the OID was related to the fact that the ASOS AT MMI consisted of the NWS observer interface, with a few minor changes. To function in an operational air traffic control (ATC) environment, where the amount of time to perform tasks is critical to safety, the AT MMI needs to be redesigned, specific to FAA needs. The following items were identified at the debriefing:

1. The OID menus should be redesigned to provide only those features that AT can, and would utilize. One main menu to cover all AT requirements should be implemented. Some functions should be executed directly from the main menu, others will require a secondary menu for execution. A sample main menu was developed.

2. The "Voice" function should be simplified; i.e., delete the necessity to go through three menus to perform a simple voice input task. A sample voice menu structure was developed.

3. To alleviate the chance of errors, the EXIT and ABORT keys should be delegated to reserved spaces on all menus; the lower right for EXIT and the upper left for ABORT.

Mean responses with Standard Deviation for Phases I and II (PH I and PH II).

Question #	Respondents		Mean		SD	
	PH I	PH II	PH I	PH II	PH I	PH II
1	26	16	2.46	2.44	1.00	1.00
2	23	15	2.43	1.87	1.73	0.00
3	24	15	2.75	3.07	1.00	1.00
4	26	14	2.19	2.14	0.00	0.00
5	25	15	2.84	2.60	1.41	1.00
6	24	14	2.62	2.29	1.41	1.00
7	25	16	3.00	3.12	1.41	1.41
8	26	16	2.54	2.12	0.00	0.00
9	25	16	3.00	2.50	1.41	0.00
10	24	16	2.79	2.88	1.41	1.00
11	26	16	2.00	2.44	0.00	1.00
12	17	13	1.88	1.92	1.00	1.00
13	25	15	2.96	2.93	1.41	1.73
14	23	15	3.30	3.53	1.41	1.73
15	25	16	2.80	2.50	1.00	0.00
16	23	16	2.48	2.25	1.00	0.00
17	21	15	4.19	3.27	2.45	1.73
18	8	10	3.75	2.90	1.73	1.73
19	15	12	3.87	3.83	2.24	1.73
20	16	13	3.69	3.38	2.24	1.41
21	12	12	3.83	2.75	2.00	1.73
22	14	11	3.21	3.18	1.73	1.73
23	11	11	4.00	4.00	2.24	2.00
24	12	10	3.33	3.00	1.73	2.00
25	13	10	3.46	3.20	1.73	1.73
26	9	13	3.89	4.08	2.00	2.24
27	9	12	4.44	3.08	1.73	1.73
28	13	10	4.00	3.50	2.24	2.00
29	11	6	4.55	3.33	2.45	1.73
30	15	11	3.13	3.09	1.73	1.73
31	17	11	2.82	2.27	1.73	1.00
32	18	11	3.22	2.64	1.73	1.41
33	19	13	3.84	3.46	2.24	1.73
34	22	13	2.95	3.15	2.00	1.73
35	25	13	2.80	2.92	1.41	2.00
36	24	13	2.54	2.92	1.41	1.73
37	24	10	2.17	3.10	1.41	1.73
38	9	12	3.89	3.42	2.00	2.00
39	19	13	1.95	2.85	1.00	1.41
40	15	9	2.67	2.44	1.73	1.41
41	16	11	1.88	1.91	1.00	1.00
42	5	6	2.20	2.00	0.00	1.00

1=Very Good 2=Good 3=Fairly Good 4=Fair 5=Fairly Poor 6=Poor 7=Very Poor

FIGURE 1. OID QUESTIONNAIRE

4. A permanent message needs to be displayed on the OID when the alarm is disabled.

5. There needs to be the capability for site specific, aural, and visual notification to AT when specified weather parameters are met; i.e., ceiling decreases to below 5000 feet.

6. The requirement for a password needs to be deleted to allow easy access by AT to the ASOS 24 hours a day.

7. The capability to enter the tower visibility via the OID must be available 100 percent of the time. The AT personnel cannot wait for the NWS personnel to sign off the NWS OID and for AT to gain system access.

8. Need message function to allow for AT to acknowledge receipt of weather from NWS when visibility is less than 4 miles.

There were several other areas of concern with the OID. One system concern was the slow response time of the system (item No. 17). This received only a "Fair" rating (Phase I) and a "Faster response time" was listed on the summary as a change that should be made to the production system. The debriefing resulted in a recommendation that the baud rate be increased to 9600 bits per second (bps) from 2400 bps.

Another area of interest, voice quality, was not addressed with a specific question, but problems were noted by the participants on the summary. The participants commented on the low volume of the controller's manually entered voice relative to the computer voice and remarked that the computer voice was too slow. The following recommendations concerning the voice feature resulted from the debriefing:

1. Need to have ability to append up to 90 seconds (increased from 30 seconds) of human voice onto the automated voice output.

2. Remarks that are appended onto the automated voice message need to remain until AT changes them, versus deletion with new hourly observation.

3. ASOS needs to modulate the human voice so that it is output at the same volume as the computer generated voice.

4. Require that AAI Corporation test and verify that the words per minute (WPM) on the computer voice meet the FAA requirement of 100 WPM.

5. Delete the requirement for the speaker which is used to review the appended voice prior to transmission. The speaker output is too noisy for a tower cab. Require a small lightweight noise cancelling microphone/handset with push-to-talk (PTT).

Another general issue concerned the lack of available space in the tower cab for the OID and its keyboard. The only questionnaire item that in any way addressed this issue was No. 14, "Placement of the display," which was rated "Fair" (Phase II). Due to space limitations in the tower cab, the OID could

not be placed at the FDO position where it belonged. The issue of available space was addressed by the participants in the summary questionnaire with the following type of comments:

1. Keyboard too large
2. Should interface with other systems
3. Clutter/ too large
4. Combine keyboard with other systems

The debriefing participants strongly urged that due to the space constraints in the tower, ASOS should interface with other systems to alleviate duplication of displays and keyboards. Since the issue of FAA systems interfacing was beyond the scope of the work group, the following recommendations were made to address ASOS as a stand alone system in the tower cab:

1. Require a smaller display for the AT OID. A flat panel display would take up less space than the large CRT provided by AAI Corporation. The display should be commercial off-the-shelf (COTS).

2. Investigate the possibility of supplying a smaller keyboard that would still provide all the functionality of the current keyboard. It was suggested that the type keyboard used with a laptop computer would meet the size requirements and be COTS.

Another item on the OID questionnaire that obtained a mean rating of "Fair" was "Warning/notification of failure" (item No. 18, Phase I). There were no comments relative to this item on the summary questionnaires and it was not addressed in the debriefing. The low rating may be a result of numerous system failures in the first 2 weeks of the evaluation.

CONTROLLER VIDEO DISPLAY (CVD).

Figure 2 presents the mean, standard deviation, and number of respondents for the CVD questionnaire, covering both Phases I and II. The mean for the Phase I responses was 3.36, and for Phase II was 3.31, an overall rating of "Fairly Good."

The CVD drew only one mean rating of "Fairly Poor," which was for item No. 3, "Readability in glare." With the exception of one questionnaire item, all the other ratings of "Fair" are related to the problem of reading the CVD. These ratings, along with the comments on the summary questionnaire speak to a critical problem with the CVD; its lack of readability in an air traffic operational setting. Some comments made regarding the readability of the CVD are as follows:

1. Glare makes screen difficult to read
2. CVD unreadable
3. Change display to reduce glare

It should be noted that even with the change of one of the CVD displays, to a "production unit" by AAI Corporation prior to the start of Phase II, the mean ratings do not reflect an improvement in readability.

Mean responses with Standard Deviation for Phases I and II (PH I and PH II).

Question #	Respondents		Mean		SD	
	PH I	PH II	PH I	PH II	PH I	PH II
1	25	15	3.84	3.93	1.73	1.41
2	22	15	2.82	3.07	1.41	1.41
3	23	15	4.57	4.73	2.24	1.00
4	19	14	3.26	3.64	1.73	1.73
5	19	14	2.95	3.50	1.73	1.73
6	23	14	2.87	3.50	1.00	1.41
7	25	15	3.48	3.67	1.41	1.41
8	24	15	4.38	4.00	2.00	1.73
9	24	15	2.17	2.40	1.00	1.00
10	23	15	3.43	3.33	2.00	2.00
11	24	15	4.08	3.93	1.73	1.73
12	25	15	3.00	2.80	1.41	1.41
13	18	12	2.72	1.83	1.41	0.00
14	20	15	3.55	3.27	2.00	0.00
15	23	15	3.22	3.47	1.41	1.00
16	22	15	3.68	3.07	1.73	0.00
17	22	14	3.41	3.14	2.00	1.41
18	21	12	3.05	2.83	1.73	2.00
19	19	12	3.42	2.83	1.73	1.73

1=Very Good 2=Good 3=Fairly Good 4=Fair 5=Fairly Poor 6=Poor 7=Very Poor

FIGURE 2. CVD QUESTIONNAIRE

The problem of CVD readability was addressed in the debriefing. It is clear that the current version of the CVD monitor is not satisfactory for FAA use. There are two problems with the CVD: (1) the white background is a problem for controllers in the radar room, and (2) glare is a problem for controllers in the tower cab. All of the screens in the radar room, save the CVD, have a black background and it is a problem for controllers in that; (1) the white screen generates a significant source of light in a working area that should be dark, and (2) it hinders the controllers' ability to do their primary duties since their eyes must adjust frequently from a "white screen" to "black screens." It was suggested that the CVD display be changed to a COTS high resolution display with a dark background that would be suitable for both the radar room and tower cab.

The second area of concern was the format of the weather information as displayed on the CVD. This item was rated "Fair" for both Phase I and II. The problem with the screen format was that it had been changed from the "standard" in use today. The participants noted the following in the summary:

1. Screen format not standard
2. Change format to current standard

The debriefing resulted in a recommendation that the weather products on the CVD appear as currently provided, and that the observation sequence shall be standard. Magnetic wind and altimeter will be highlighted within the standard format. It was also recommended that the following elements be deleted; (1) pressure altitude, (2) sea level pressure and relative humidity, and (3) density altitude be available on a site-by-site basis.

In addressing the issue of available space, it was recommended that the information on the CVD be displayed on available displays in the radar room such as the System Atlanta Information Display System (SAIDS). The recommendation was made to investigate the possible interface of ASOS into the SAIDS displays where available.

VIDEO DISPLAY UNIT (VDU).

Only two VDU questionnaires were returned for each evaluation phase. Due to this low response no analysis was performed on the questionnaire data. The only comment received on the summary questionnaire specific to the VDU was "Undesirable location."

SUMMARY QUESTIONNAIRE.

The comments received on summary questionnaire items 1 to 5 and 8 and 9 provide the details to explain each rating of Fair or lower and were detailed in the discussions of each display. There were two questionnaire items that asked for an overall assessment of ASOS. Question 6, "Do you see ASOS as a help or hinderance on your job?" received 16 positive and no negative responses for Phase I, and 11 positive and 2 negative for Phase II. This positive rating, along with the rating of "Fairly Good" (Phases I and II) on item 7 "Suitability of ASOS for operational use?" corresponds with the mean ratings for both the OID and CVD of "Fairly Good."

CONCLUSIONS

The evaluation of the AAI Corporation's preproduction Automated Surface Observing System (ASOS) by the tower air traffic control (ATC) personnel at Tulsa International Airport, Oklahoma, has provided significant input on the operational suitability of Automated Surface Observing System (ASOS) in an Federal Aviation Administation (FAA) ATC environment. Some of the significant findings are:

1. The Operator Interface Device (OID) man machine interface is not suitable for ATC operations,

2. Voice quality is unacceptable,

3. The system response rate is too slow,

4. The OID and keyboard are too large for the operational environment,

5. Controller Video Display (CVD) is not readable in the tower cab or radar room,

6. Format of weather products on the CVD is not standard.

Even with the problems cited, the evaluation participants rated the system overall "Fairly Good" and noted that with changes it would be suitable for operational use.

RECOMMENDATIONS

The proposed changes to the preproduction Automated Surface Observing System (ASOS), that were derived from the Tulsa debriefing, reflect only the recommendations and viewpoint of one group of users. There is a considerable amount of risk involved if the proposed changes from the Tulsa evaluation are incorporated into the specification without further evaluation by controllers from sites other than Tulsa. To help insure acceptability by field personnel, a second evaluation of the preproduction ASOS is highly recommended.

If a second evaluation of the preproduction ASOS is not possible, the recommendations derived from the Tulsa debriefing should be integrated into the air traffic (AT) requirements for ASOS and presented to the National Weather Service (NWS) for inclusion into the production specification.

Since the area of display readability is highly critical to fielding the ASOS at air traffic control towers, an additional evaluation of displays should be conducted at the FAA Technical Center in order to determine a technology that will be appropriate for the AT application. This evaluation should be conducted prior to production contract award so that the recommended display can be incorporated into the limited production systems.

It is also recommended that a user evaluation of the limited production ASOS be conducted prior to the decision for full deployment. It is recommended that the Federal Aviation Administration (FAA) perform a limited operational test and evaluation (OT&E) of ASOS at both the FAA Technical Center and a minimum of two operational sites. The FAA Technical Center evaluation would incorporate a cross section of controllers from all FAA regions and could be accomplished by moving up the installation date for the Atlantic City International Airport system. The evaluations at operational sites should include at least one site with a Terminal Radar Approach Control (TRACON) and incorporate towers of different traffic activity to provide user diversity in the evaluations.

ACRONYMS AND ABBREVIATIONS

AF - Airways Facilities

ASOS - Automated Surface Observing System

AT - Air Traffic

ATC - Air Traffic Control

ATCS - Air Traffic Control Specialist

ATCT - Airport Traffic Control Tower

bps - bits per second

COTS - commercial off-the-Shelf

CVD - Controller Video Display

FAA - Federal Aviation Administration

FDO - Flight Data Operator

MMI - Man Machine Interface

MOA - Memorandum of Agreement

NAS - National Airspace System

NOAA - National Oceanic and Atmospheric Administration

NWS - National Weather Service

OID - Operator Interface Device

OT&E - Operational Test and Evaluation

PTT - push to talk

SAIDS - System Atlanta Information Display System

SAO - Surface Aviation Observation

SR&DC - Sterling Research and Development Center

VDU - Video Display Unit

WPM - words per minute

FAA Air Traffic Operational Evaluation of ASOS

OID

Tower _____ **FDO** _____
Date _____ **Controller** _____

Read each statement carefully. Then to the right of each statement mark your evaluation of each feature. Mark only one answer for each item. If you have not used the particular feature or piece of equipment mark "Do Not Know."

	Very Good	Good	Fairly Good	Fair	Fairly Poor	Poor	Very Poor	Do Not Know
DISPLAY								
1. Daytime readability	O	O	O	O	O	O	O	O
2. Nighttime readability	O	O	O	O	O	O	O	O
3. Readability in glare	O	O	O	O	O	O	O	O
4. Use of color	O	O	O	O	O	O	O	O
5. Noticeability of highlighted messages	O	O	O	O	O	O	O	O
6. Readability of highlighted messages	O	O	O	O	O	O	O	O
7. Screen format	O	O	O	O	O	O	O	O
8. Size of alphanumerics	O	O	O	O	O	O	O	O
9. Readability of alphanumerics from the normal operating position	O	O	O	O	O	O	O	O
10. Adjustability of brightness & contrast for all lighting conditions	O	O	O	O	O	O	O	O
11. Screen size	O	O	O	O	O	O	O	O
12. Screen flicker	O	O	O	O	O	O	O	O
13. Location of function/control keys	O	O	O	O	O	O	O	O
14. Placement of the display	O	O	O	O	O	O	O	O
15. Angle of the display	O	O	O	O	O	O	O	O
16. Adjustability of the display	O	O	O	O	O	O	O	O
SYSTEM								
17. Speed of system response	O	O	O	O	O	O	O	O
18. Warning/notification of failure	O	O	O	O	O	O	O	O
19. Effort required to append remarks	O	O	O	O	O	O	O	O
20. Effort required to input tower visibility	O	O	O	O	O	O	O	O
21. Effort required to mark an element "missing"	O	O	O	O	O	O	O	O

FAA Air Traffic Operational Evaluation of ASOS

OID

Tower _____ **FDO** _____
Date _____ **Controller** _____

Read each statement carefully. Then to the right of each statement mark your evaluation of each feature. Mark only one answer for each item. If you have not used the particular feature or piece of equipment mark Do Not Know.

	Very Good	Good	Fairly Good	Fair	Fairly Poor	Poor	Very Poor	Do Not Know
SYSTEM								
22. Effort required to generate & store obs.	O	O	O	O	O	O	O	O
23. Effort required to switch voice output	O	O	O	O	O	O	O	O
24. Effort required to archive data	O	O	O	O	O	O	O	O
25. Effort required to view archived data	O	O	O	O	O	O	O	O
26. Effort required to input/erase voice message	O	O	O	O	O	O	O	O
27. Effort required to verify voice message input	O	O	O	O	O	O	O	O
28. Effort required to input frequently changing data	O	O	O	O	O	O	O	O
29. Effort required to recover from an input error	O	O	O	O	O	O	O	O
30. Prompting/cues for multi-step tasks	O	O	O	O	O	O	O	O
31. Ease of use on "VFR" wx days	O	O	O	O	O	O	O	O
32. Ease of use on "IFR" wx days	O	O	O	O	O	O	O	O
33. Interaction with other ATC tasks	O	O	O	O	O	O	O	O
34. Access to the system	O	O	O	O	O	O	O	O
KEYBOARD/MICROPHONE/ALARM								
35. Layout of keyboard	O	O	O	O	O	O	O	O
36. Position of keyboard	O	O	O	O	O	O	O	O
37. Adjustability of keyboard	O	O	O	O	O	O	O	O
38. Ease of use of the microphone	O	O	O	O	O	O	O	O
39. Audibility of the alarm	O	O	O	O	O	O	O	O
40. Adjustability of the alarm	O	O	O	O	O	O	O	O
41. Disabling of alarm	O	O	O	O	O	O	O	O
42. False alarm rate	O	O	O	O	O	O	O	O

APPENDIX B

ATC FUNCTIONAL REQUIREMENT SCENARIOS for the AUTOMATED SURFACE OBSERVING SYSTEM (ASOS) OID

1. Sign on at the OID position

2. Adjust the display to your liking.

3. Enter tower visibility as 3 1/2 miles.

4. Enter tower visibility as 2 miles.

5. Enter tower visibility as 1 mile.

6. Generate a local observation for an aircraft mishap.

7. Archive 2 hours of 5 minute observations for an aircraft mishap (one hour before and after time desired)

8. Generate a remark "funnel cloud NW movg N".

9. Using the microphone, add the above remark to the voice message. Listen to playback before insertion into message.

10. Generate the remark "CB N" and add to voice but before actual insertion change direction to W.

11. Erase the voice message in 10.

12. Mark the temperature as "missing".

13. Review hourly observations for the past 24 hours.

14. Switch from broadcast of hourlies and special observations to minute-by-minute observations. Add the following by microphone: "ABC tower ceased operations at 2000 local. Common traffic advisory frequency is 122.9. For additional support contact XYZ approach control on 124.3. ABC tower will resume normal operations at 0600 local."

ATC FUNCTIONAL REQUIREMENT SCENARIOS - **SOLUTIONS**

1. At the one-minute screen, depress the SIGN key. Enter your initials (2 or 3 characters, A-Z) <Return>. Enter password (FAAMAN, during the training period) and strike <Return>.

   All of the following commands are entered starting from the one-minute screen and with the Air Traffic Controller signed into the ASOS system.

2. Personal Liking

3. EDIT-TWR-(Enter a reportable value - 3 1/2, <Return>)-EXIT

4. EDIT-TWR-(Enter 2, <Return>)-EXIT

5. EDIT-TWR-(Enter 1, <Return>)-EXIT

6. GENOB-LOCAL-EDIT-(Use "NEXT" function key to go to the Remarks section)-(Enter "(ACFT MISHAP)")-EXIT

7. REVUE-OBS-(5-MIN)-ARCH2H-(Enter time (LST) and make sure the colon (:) is entered. Time entered is the start time of the 2-hr block of data)-EXIT

8. EDIT-(Use NEXT to get down to Remarks section)-(Enter: FUNNEL CLOUD NW MOVG N)-EXIT

9. CMD-VOICE-TYPE-(Page options to ONE MINUTE)-RCORD-(Follow system's prompts)-RPLAY-EXIT

10. EDIT-(Use the "NEXT" function key to get to remarks)-(Enter: CB N, Use the "REMOVE" key to erase the N and enter a W)-EXIT

    Voice Section: CMD-VOICE-RCORD-(Space Bar - Say "CB N" - Space Bar)-RPLAY-RCORD-(Space Bar - Say "CB W" - Space Bar)-RPLAY-NOTAM-(Toggle to YES)-EXIT

11. CMD-VOICE-NOTAM-(Toggle to NO)-EXIT

12. REVUE-SENSR-CONFG-(Move Cursor Down to H083)-PROC-(Enter Initials), <Return>, EXIT. Temperature and Dewpoint will go to missing in about a minute on the one-minute screen.

13. REVUE-OBS-SAO-(Use PREV and NEXT keys as necessary. Or, use the DATE option and enter the date in LST.)-EXIT

14. CMD-VOICE-TYPE-(Toggle through to ONE MINUTE in the CURRENT AIRPORT OUTPUT = line.)-RCORD-(follow the system's prompts)-RPLAY-NOTAM-(Toggle to YES)-EXIT

APPENDIX C

FAA Air Traffic Operational Evaluation of ASOS

VDU

Tower _____ **FDO** _____
Date _____ **Controller** _____

Read each statement carefully. Then to the right of each statement mark your evaluation of each feature. Mark only one answer for each item. If you have not used the particular feature or piece of equipment mark Do Not Know.

	Very Good	Good	Fairly Good	Fair	Fairly Poor	Poor	Very Poor	Do Not Know
DISPLAY								
1 Daytime readability	O	O	O	O	O	O	O	O
2 Nighttime readability	O	O	O	O	O	O	O	O
3 Readability in glare	O	O	O	O	O	O	O	O
4 Color of display	O	O	O	O	O	O	O	O
5 Screen format	O	O	O	O	O	O	O	O
6 Size of alphanumerics	O	O	O	O	O	O	O	O
7 Readability of alphanumerics from the normal operating position	O	O	O	O	O	O	O	O
8 Adjustability of brightness & contrast for all lighting conditions	O	O	O	O	O	O	O	O
9 Screen size	O	O	O	O	O	O	O	O
10 Screen flicker	O	O	O	O	O	O	O	O
11 Placement of the display	O	O	O	O	O	O	O	O
12 Angle of the display	O	O	O	O	O	O	O	O
13 Adjustability of the display	O	O	O	O	O	O	O	O
SYSTEM								
14 Interaction with other ATC tasks	O	O	O	O	O	O	O	O
15. Ease of use on VFR wx days	O	O	O	O	O	O	O	O
16. Ease of use on IFR wx days	O	O	O	O	O	O	O	O

APPENDIX D

FAA Air Traffic Operational Evaluation of ASOS

CVD

Tower _____ **FDO** _____
Date _____ **Controller** _____

Read each statement carefully. Then to the right of each statement mark your evaluation of each feature. Mark only one answer for each item. If you have not used the particular feature or piece of equipment mark Do Not Know.

	Very Good	Good	Fairly Good	Fair	Fairly Poor	Poor	Very Poor	Do Not Know
DISPLAY								
1 Daytime readability	O	O	O	O	O	O	O	O
2 Nighttime readability	O	O	O	O	O	O	O	O
3 Readability in glare	O	O	O	O	O	O	O	O
4 Noticeability of highlighted messages	O	O	O	O	O	O	O	O
5 Readability of highlighted messages	O	O	O	O	O	O	O	O
6 Highlighting of wind and altimeter data	O	O	O	O	O	O	O	O
7 Color of the display	O	O	O	O	O	O	O	O
8 Screen format	O	O	O	O	O	O	O	O
9 Size of alphanumerics	O	O	O	O	O	O	O	O
10 Readability of alphanumerics from the normal operating position	O	O	O	O	O	O	O	O
11 Adjustability of brightness & contrast for all lighting conditions	O	O	O	O	O	O	O	O
12 Size of screen	O	O	O	O	O	O	O	O
13 Screen flicker	O	O	O	O	O	O	O	O
14 Placement of the display	O	O	O	O	O	O	O	O
15 Angle of the display	O	O	O	O	O	O	O	O
16. Adjustability of the display	O	O	O	O	O	O	O	O
SYSTEM								
17 Interaction with other ATC tasks	O	O	O	O	O	O	O	O
18 Ease of use on "VFR" wx days	O	O	O	O	O	O	O	O
19. Ease of use on "IFR" wx days	O	O	O	O	O	O	O	O

FAA Air Traffic Operational Evaluation of ASOS

ASOS SYSTEM
ATCS Operating Initials_____ Supervisor _____
Tower _____ FDO _____
Date _____ Controller _____

Please provide us with your evaluation of the overall ASOS system. Explanations of your answers are important for feedback to the contractors and improvements to the system. THANK YOU!!!

1. Please explain any rating of "Fairly Poor" or lower. _____

2. What benefits do you see from ASOS ? (explain) _____

3. What problems do you see from ASOS ? (explain) _____

4. Most desirable feature of ASOS. (explain) _____

5. Least desirable feature of ASOS. (explain) _____

6. Do you see ASOS as a help or hindrance on your job ? (explain) _____

7. Suitability of ASOS for operational use ?

Very Good_____ Good_____ Fairly Good_____ Fair_____
Fairly Poor_____ Poor_____ Very Poor_____ Do Not Know_____

8. Please list any changes you feel should be made to the pre- production ASOS ? _____

9. General Comments: _____

If you need extra space for writing, continue on the back.

APPENDIX F

ASOS EVALUATION RESPONSE ALTERNATIVES

1. **VERY GOOD**
The action taken, as described, was effortless. The MMI design is outstanding. Operational use of this feature is highly desirable from a controller's prospective.
FOR EXAMPLE:
a. Imputing tower visibility is both quick and easy.
b. Brightness and contrast are exceptional.

2. **GOOD**
The action taken, as described, was almost effortless. The MMI design is excellent. Operational use of this feature is desirable from a controller's prospective.
FOR EXAMPLE:
a. Imputing tower visibility is easy.
b. Brightness and contrast are extremely effective in sunlight.

3. **FAIRLY GOOD**
The action taken, as described, took a little effort which did not interfere with normal job function. The MMI design is satisfactory. Operational use of this feature is useful from a controller's prospective.
FOR EXAMPLE:
a. Imputing tower visibility is easy once prompt is displayed.
b. Brightness and contrast are fairly good.

4. **FAIR**
The action taken, as described, took an acceptable amount of effort. The MMI design is mediocre and could use some modifications. Operational use of this feature adds nothing to the system.
FOR EXAMPLE:
a. Imputing tower visibility takes a little too much time unless you know the functions.
b. Brightness and contrast are fair in direct sunlight.

5. **FAIRLY POOR**
The action taken, as described, was difficult. The MMI design is workable with changes. Operational use of this feature is awkward.
FOR EXAMPLE:
a. Imputing tower visibility requires too much time.
b. Brightness and contrast could be better in direct sunlight.

6. POOR
The action taken, as described, was too difficult without major changes. The MMI design needs major improvements.Operational use of this feature is difficult in conjunction with other duties.
FOR EXAMPLE:
a. Imputing tower visibility via keyboard and waiting for prompt takes too much time.
b. Brightness and contrast are poor.

7. VERY POOR
The action taken, as described, was unacceptable. The MMI design is unacceptable. Operational use of this feature is detrimental to other duties.
FOR EXAMPLE:
a. Imputing tower visibility via keyboard takes too much time away from primary job functions.
b. Brightness and contrast controls have no effect in direct sunlight.

U.S. Department of Transportation
Federal Aviation Administration

Memorandum

Subject: INFORMATION: Executive Summary of the FAA ASOS Evaluation Conducted at Tulsa, OK

Date: JUN 08 1990

From: Technical Program Manager, ACN-230

Reply to Attn of: E. Turcich

To: ASOS Project Manager, ANW-140

The following is a summary of the results obtained from the evaluation of the AAI Corp. Automated Surface Observing System (ASOS) installed in the Tulsa Air Traffic Control Tower. This summary contains only the highlights of the results, and is being prepared for use by the National Weather Service (NWS). This summary will be followed by a full evaluation report to be completed 60 days after the Wichita Evaluation is complete.

The Engineering Test & Evaluation Service, ACN-230, of the FAA Technical Center, conducted an evaluation of the ASOS system by Tulsa tower personnel from April 16 to May 26. NWS trained 7 supervisors/controllers on the system from April 16 to April 20. During the week of April 23 to April 27, ACN-230 personnel trained 47 controllers on the ASOS system, in addition to briefing 54 supervisors/controllers on the evaluation and the questionnaires. The controllers evaluated the system during the week of April 30 (Phase I), and again during the week of May 21 (Phase II).

Results
The following is a table of the completed questionnaires:

Questionnaire	Phase I	Phase II
OID	27	16
CVD	24	15
VDU	2	2
Summary	22	14

The low response during Phase II may be due to the short time period between Phases I and II. The low response rate on the VDU for both Phases may be a result of the placement of the display. The display was placed across the room from the supervisors desk - approximately 20 feet away.

A summary of the results is as follows:

The mean response to the question "Suitability of ASOS for operational use ? " was:

Phase I - Fairly Good (3 on a scale of 7)
Phase II Fair (4 on a scale of 7)

There were only two statements that were given a mean rating of "Fairly Poor" (5 on a 7 point scale) on the Phase I questionnaires. These were:

1) (OID) The effort required to recover from an input error
2) (CVD) Readability in glare

For the Phase II questionnaires the CVD readability was again rated "Fairly Poor".

In general, the mean ratings on individual items improved on the Phase II questionnaires. In both Phase I and II, there were many mean ratings of "Fair" (4 on a 7 point scale). These ratings are best described by the written responses on the summary questionnaire.

The most frequent comments relating to <u>problems</u> with ASOS are as follows:

CVD
- Glare makes screen difficult to read
- Screen format is not standard
- Highlighted areas have poor contrast

OID
- System response too slow
- Volume on controller voice is too low
- Too large/ clutter
- Too many steps to input voice message
- Not user friendly/too many inputs
- Computer voice too slow

General
- Should interface with SAIDS/ATIS/AWIS
- Slow in responding to Wx changes
- Inaccurate sky coverage

The most frequent <u>benefits</u> of ASOS were listed as follows:

- Timely/current weather updates
- Greater accuracy
- Automated voice broadcast

There were several well thought out suggestions for improving the system that were each made by only 1 or 2 respondents. These should be considered to make the system more effective for an air traffic control environment.

Recommendation

The results show that the AAI Corp. ASOS, with modifications, would be suitable in an air traffic control tower. Beyond the major problems with display format and readability, and system response time, the majority of comments were concerned with the effort required to accomplish ASOS tasks. In an air traffic environment the weather observing/recording, although extremely important, is secondary to other air traffic control tasks. The FAA utilizes only a small number of the functions available on ASOS. The system would better serve the controller if all non-FAA functions were removed from the FAA OMD, and the functions that are allowed were made simpler to utilize.

If you have any questions, please contact E. Turcich at FTS 482-6784.

Elizabeth Turcich for

Frances A. Mackuse

cc:
B. Ware, DTC

APPENDIX H

SUMMARY QUESTIONNAIRE
WRITTEN RESPONSE

Q.1 Explain any rating of "Fairly Poor" or lower.
respondents:
Phase I = 15
Phase I = 10

		Phase I	Phase II
CVD:	Glare makes screen difficult to read	10	5
	Screen format not standard	2	5
	Screen size too large	1	2
	Highlighted areas have poor contrast	0	3
	Requires continual adjustment	0	1
	Change color of display	0	1
OID:	Response too slow	4	2
	Keyboard too large	2	1
	Need perm. message for alarm disabled	2	0
	Screen format is poor	2	0
	Screen too dark-couldn't adjust	1	0
	Glare makes it difficult to read	1	1
	Simplify keyboard entries	1	0
	Simplify voice input	1	2
	ID entries by initial only	1	1
	Locate display near operator	1	1
	Make alarm volume adjustable	1	0
	Highlighted messages were unrecognizable	1	0
	F-3 caused system crash	1	0
	Font is too small	1	0
	Does not warn of approaching severe WX	0	2
	Tower should be able to print "obs"	0	1
	Controller voice has low volume	0	3
	Remarks should be retained	0	1
	Allow "AT" input with NWS logged on	0	1
VDU:	Undesirable location	0	1
GENERAL:	Should interface with SAIDS & AWIS	1	2

Q.2 What benefits do you see from ASOS ?
respondents:
Phase I = 20
Phase I = 13

	Phase I	Phase II
Timely / current weather updates	15	12
Greater accuracy	3	0
Automatic broadcast	1	0
Reduced controller workload	2	1
Long term cost saver	1	0

If combined with SAIDS, ATIS and/or AWIS would be time & cost saver	3	2

Q.3 What problems do you see from ASOS ?
respondents:

Phase I = 16
Phase II = 13

	Phase I	Phase II
Too slow in responding to WX changes	4	2
Inaccurate sky cover	3	2
Clutter/ too large	3	2
CVD unreadable	2	2
Need more time for voice message	1	2
What happens if system crashes	1	0
1 min. updates vary too greatly	1	0
Doesn't detect fog or smoke	1	1
Not being interfaced with ATIS	1	0
None observed / foreseen	2	0
Too many steps required to input voice msgs.	0	5
Message format	0	1

Q.4 Most desirable feature of ASOS ?
respondents:

Phase I = 17
Phase II = 11

	Phase I	Phase II
Constant/timely WX updates	10	8
Automated voice broadcast	3	1
All Wx in one location	1	0
No delay in change from VFR to IFR	1	0
Takes work out of visibility values	1	0
Reduce workload	0	2

Q.5 Least desirable feature of ASOS ?
respondents:

Phase I = 16
Phase II = 12

	Phase I	Phase II
OID not user friendly/too many inputs	4	2
CVD screen	3	3
Equip. too large/ no room	2	0
Limitations on sky & visibility	2	0
Signing on/off	1	0
CVD not conforming to OID	1	1
Chance of computer outage	1	1

Location of OID	1	1
Not controller proof/crashes	1	0
Too slow	1	0
Inability to determine precip.	1	0
Not interfaced with other systems	1	1
None	1	0
Computer voice too slow	0	3

Q.6 Do you see ASOS as a help or hindrance on your job ? Explain.
respondents:

Phase I = 18
Phase II = 13

	Phase I	Phase II
Help	18	11
Hindrance	0	2

Comments:

Current Wx	5	5
With modifications	5	2
Reduced workload	2	1
Automated voice	1	1
Increased accuracy	1	0
Reduce time on change from VFR to IFR	1	0
Misc	3	2
Hindrance until improvements are made	0	2

Q.7 Suitability of ASOS for operational use?
respondents:

Phase I = 19
Phase I = 13

Mean response:

Phase I = Fairly good
Phase II = Fair

Q.8 Please list any changes you feel should be made to the pre-production ASOS.
respondents:

Phase I = 15
Phase II = 11

	Phase I	Phase II
CVD:		
Change display to reduce glare	4	3
Change format to current standard	4	3
Change display to LED	2	1
Reduce size of CVD	1	0
Redesign the display	1	0
OID:		
Faster response time	3	0

Smaller keyboard	1	2
Combine monitors & keyboards	1	0
Use single entry keys	1	3
Eliminate non ATC functions	1	0
Better graphics	1	0
Voice quality and speed	0	7
Alert "ATC" of special "obs"	0	1
General:		
Combine with ATIS	4	0
Better precip. determination	1	0
Combine FDIO/SAIDS/ASOS keyboards	1	2

Q.9 General comments
respondents:

Phase I = 15
Phase I = 9

		Phase I	Phase II
CVD:	Change WX Format	1	0
	Readability	0	2
	Erroneous data	0	1
	CVDs are unusable	1	1
OID:	Should be in an accessible location	1	0
	Screen has reflections	0	1
	Use "zulu" time	0	1
	Should have "alert" feature for specials	0	1
	Voice recording volume unacceptable	0	1
	Computer generated voice acceptable	0	1
	Difficulty using modem	0	1
	Desirable if able to append information via keyboard	0	1
General:			
	Combine with ATIS/SAIDS/AWIS	5	2
	Nice/Good start	3	1
	Good with modifications	2	1
	Easy to learn	1	1
	Longer training program would help	1	0
	What happens when failure occurs ?	1	0
	Stupid to non-interfacing system	1	0
	Equip inoperative when attempted to use	1	0
	Current WX displayed at each position	0	1
	A few design flaws	0	1
	Current wind information desirable	0	1
	Too easy to "bomb" system	0	1